LOW TEMPERATURE GALVANISING.

THE coating of iron with zinc in order to protect it from atmospheric corrosion is an industry which dates back to 1846, and is employed upon a very large scale. The original process, and still the chief one in vogue, was to dip the cleaned iron surface into a bath of molten zinc. The zinc forms an alloy upon the surface of the iron, and as zinc is very little acted upon by the atmosphere, whereas iron rapidly rusts and corrodes, a protective coating is obtained. Furthermore, in the case of tanks, buckets, &c., it is not necessary that the joints should be absolutely water-tight, because when dipped into the molten zinc any slight leaks are filled in with this metal.

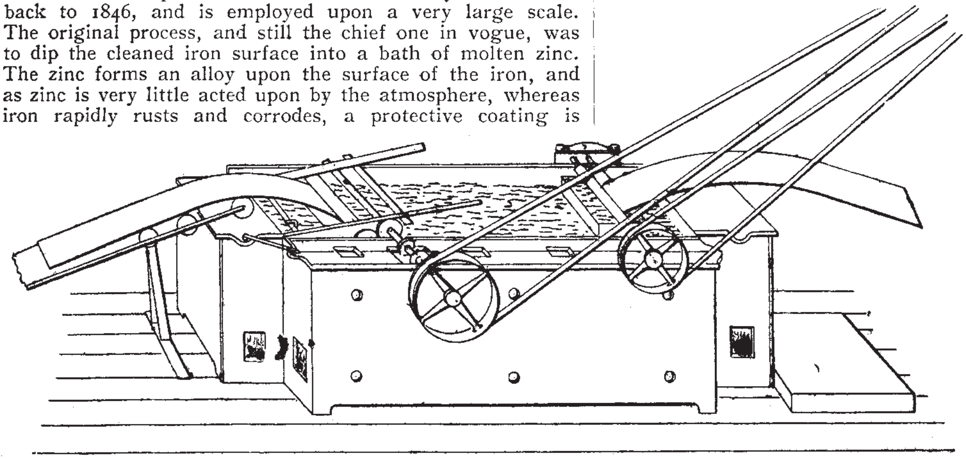


Fig. 1.

The great advantage of employing zinc as a coating for iron is that it is electropositive to this metal, and thus the tendency is for the zinc to go into solution and become oxidised, instead of the iron with which it is in contact being acted upon. The zinc, however, takes on a protective coating of oxide or oxycarbonate, and thus further corrosion is prevented, or at any rate will only take place very slowly.

There are, however, disadvantages in connection with hot galvanising. In the first place it is expensive to keep large quantities of zinc in the molten condition. Secondly, there is considerable loss of zinc through oxidation. Thirdly, the zinc tends to alloy with the iron and to form a difficultly fusible alloy. The higher the temperature of the bath the greater the tendency for alloy formation, but, on the other hand, the thinner the coating obtained upon the metal to be galvanised, and thus in this direction a saving in cost. The alloy of iron and zinc produced is extremely hard, and is sometimes used for making bearings, but as it is difficult to separate the iron from the zinc it is a distinct disadvantage to the galvaniser. Finally, the hot zinc is apt to destroy the temper of the iron, and sometimes to distort the shape of the article to be galvanised.

Consequently, it is necessary to keep the bath at as low a temperature as possible, the excess of zinc being removed by passing the sheets through rollers (Fig. 1).[1]

Cold galvanising or electrolytic galvanising has therefore been suggested, and is actually employed for specific purposes, but there are a good many reasons which have prevented it coming into general use. In the first place, the articles to be galvanised require a more thorough cleansing than is the case with hot galvanising, the least trace of grease being fatal to a good deposit. If there happen to be flaws or the joints are not quite tight, these are not filled in by the wet galvanising process. There are also difficulties in connection with the use of zinc anodes owing to disintegration. As a rule, therefore, lead or iron anodes are employed, and the strength of the electrolyte is maintained constant by circulating it through a filter bed consisting of coke and powdered zinc or coke and zinc oxide (Fig. 2). The disadvantage that flaws are not coated by electrolytic galvanising is in certain cases made use of.

For example, steam tubes employed for marine boilers may have slight flaws which are practically impossible to locate by mere inspection, but which, if the tubes were actually used in boiler construction, might lead to very serious accidents. If such tubes are electro-galvanised, the flaws are made apparent owing to the inequality of the galvanising, probably partially produced by local action.

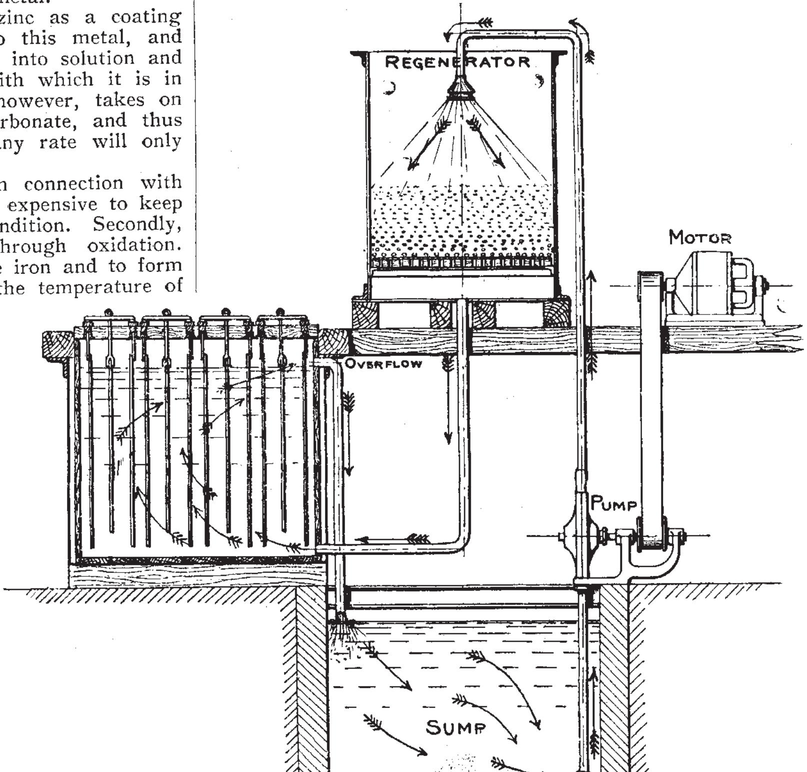


Fig. 2.

Therefore electro-galvanising has been, and is, employed for coating steel tubes used for the construction of boilers for the navy, not to act as a protective coating, but in order to expose flaws or inequalities.

Electro-deposited zinc is of a uniform grey colour, and does not exhibit the artistic crystalline structure produced in hot galvanising. It is very even, and takes on a beautiful polish, so that actually it can be made more artistic than zinc deposited by hot galvanising, which, owing to its crystalline structure, cannot very well be polished.

---

[1] The diagrams accompanying this article have been reproduced from the Transactions of the Glasgow Technical College Scientific Society from a paper read by Mr. S. Cowper-Coles.

But beside the actual cold galvanising and the galvanising by means of molten metal, there is a low temperature dry process which was accidentally discovered by Mr. Sherard Cowper-Coles some little time ago. In order to temper certain articles, Mr. Cowper-Coles imbedded them in zinc powder, and they were then heated to a temperature which was considerably below the fusing temperature of zinc. After cooling the articles were taken out, and were, to the surprise of the operator, found to be homogeneously coated with metallic zinc. The zinc was firm and adherent, and on cutting a rod of metal through, it was found that the zinc had penetrated an appreciable depth into the other metal. Experiments were then undertaken to ascertain what was the lowest temperature which could be employed, and whether all metals would thus react with the zinc. It was found that metals could be evenly and completely coated with zinc by heating to a temperature of from 250° C. to 330° C. (zinc melts at 418° C.). The process is now called Sherardising, after the name of the inventor, and is worked essentially as follows:—

Zinc dust, which is obtained as a by-product in the metallurgy of zinc, is the raw product employed. This substance, which amounts to about 10 per cent. of the zinc produced, and can therefore readily be obtained in large quantities, consists of very finely divided zinc mixed with considerable quantities of oxide. Scale and oxide are removed from the articles to be coated; this, of course, is also necessary in all other galvanising processes. In other processes, however, it is also necessary to remove grease, but in this dry galvanising the removal of grease is not necessary, and its presence, at any rate in small quantities, appears to be a distinct advantage. After the scale has been removed the articles are placed in a closed iron receptacle, and the zinc dust charged in; the containing box may be arranged either to work stationarily or rotated. The temperature is then raised to 250° C. to 330° C. by means of gas firing, and maintained so for from half an hour to several hours, depending upon the coating required and the nature of the article to be coated. The drum is then allowed to cool, and discharged. Owing probably to the individual grains of zinc in zinc dust being coated with oxide, it is a very difficult matter to cause it to melt together even when the temperature is raised far above its melting point. This is one of the troubles met with in the metallurgy of zinc, that is, there is a tendency for the metal to condense as dust and not to run together and liquefy. But in the Sherardising process this is a distinct advantage, because, should the drum become overheated, there will be no danger in its melting together and spoiling the articles to be galvanised.

In order, so far as possible, to prevent increase in oxide during heating, the receptacle is preferably made air-tight, but when this is not possible about 3 per cent. of fine charcoal is added to the zinc. Otherwise, as the quantity of oxide increases, the deposit lacks in lustre. The fact that small quantities of grease do not prevent the production of a good deposit is of importance, because it enables machined work, such as bolts, screws, &c., to be placed directly into the galvanising drum without previous cleaning. For small articles, such as screws, rings, nuts, &c., a closed iron cylinder which can be rotated or oscillated is the most suitable form of furnace. For tubes, oblong or cylindrical work, it is most satisfactory to have the door at the end of the furnace, and oscillate it on its axis. A number of Bunsen burners are arranged below the drum, and the whole is enclosed in an iron shell lined with asbestos. For larger work, stationary iron boxes are employed, as illustrated in Fig. 3.

A plant has been erected near London containing four furnaces capable of taking drums 6 feet by 2 feet, with a cubic capacity of two tons of material at one charge. The furnaces are heated with Dowson gas. It is essential that the zinc dust be dry before being added to the furnace, otherwise the zinc is oxidised, and hydrogen is given off on heating.

It is stated that in practice dry galvanised or Sherardised steel and iron will withstand the ordinary corrosive agents to which galvanised ware is usually exposed to a remarkable degree. Even after the apparent removal of the zinc by abrasion, the iron will retain its resistivity.

This resistivity is probably due to the protective action of the zinc-iron alloy formed below the actual zinc coating. The temper of steel wire is not reduced by dry galvanising, owing to the low temperature at which the process is carried out. In Sherardising, the zinc does not form a more or less thick coating or skin, but actually sinks into the metal. As a consequence, the fine lines of screws and other articles which have been machined are not blurred. For example, the minute screws which are employed in making watches can be Sherardised, and fit the holes tapped to receive them quite as well as before being zinced.

In the ordinary method of galvanising it has not been found possible to produce patterns, because, of course, the whole article has to be dipped, and there are also difficulties in doing this with electrolytic galvanising owing to the electrolyte getting beneath the stopping material which may be used; but with the Sherardising process it has been found possible to produce some very artistic effects. In order to do this, the article is coated with a stopping-off composition. The composition is about the consistency of soap, so that it can be easily cut with a knife. The design is traced with an edged tool, and the portions to be removed are lifted away, so that a clean surface is exposed to the action of the zinc. The object so prepared is placed in an iron drum containing the metal which is to be inlaid in the powdered form, for example, the zinc dust. The galvanising is then carried out as already described.

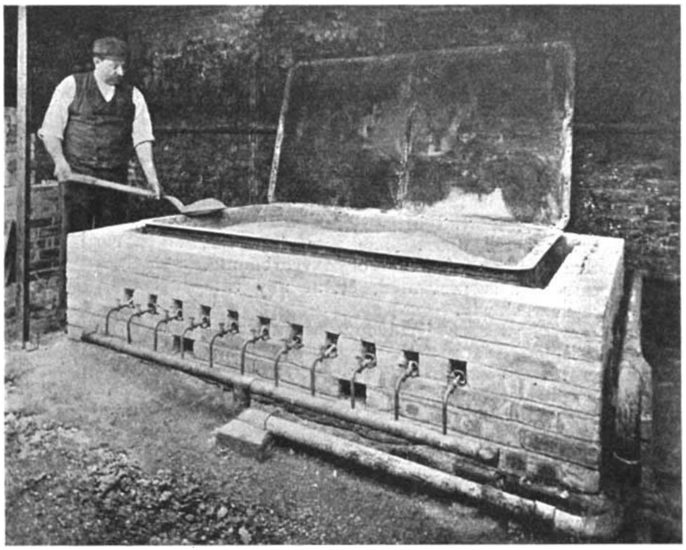


Fig 3

The temperature and the time which the heating has to be continued are regulated according to the thickness which is required for the inlaying, and may vary from a few minutes to several hours. After inlaying it is found that the part inlaid is much harder than the brass or copper into which it is inlaid.

Furthermore, it is possible to obtain a variety of colours by means of the process. Suppose, for example, one wishes to inlay a copper vase, and convert some parts of it into brass; this can be done by variations in the thickness of the stopping-off composition and by heating to a higher temperature than is generally done. By proceeding in this manner some portions can be converted into yellow-coloured brass, and other parts remain pure copper.

The contrasts between copper and brass are very marked, but softer effects can be obtained with zinc, aluminium, tin, and other metals. Fig. 4 shows such an inlaid copper vase.

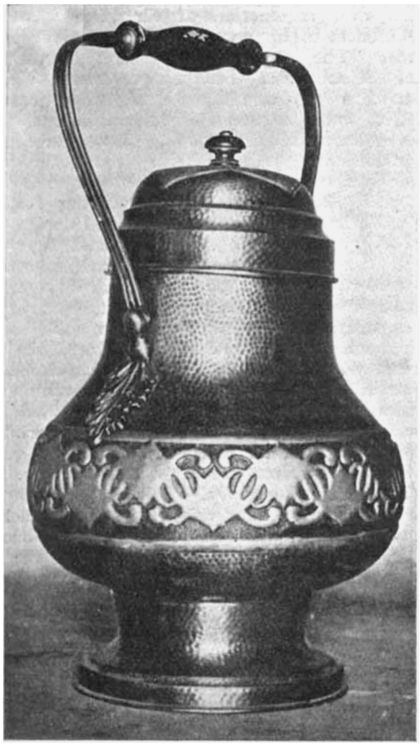


Fig. 4.—Copper and brass coal vase inlaid with zinc.

One beauty about this process of inlaying metals which differentiates it from other processes is the soft transition which shades the inlaid metal from the surrounding metal. For instance, it will be observed that when inlaying zinc into copper, the zinc is surrounded by a halo of the brass-coloured alloy.

Mr. Cowper-Coles has also another process, which he calls Cowperising, and in which he uses vapour of zinc; the articles to be coated are *not* brought into contact with dry or molten zinc, but are placed in a chamber into which zinc vapour is passed. The chamber or drum is slowly rotated inside an outer cylinder in which the metallic zinc is heated by means of a gas or electric furnace. Hydrogen gas is also passed into the apparatus from a tube, and a pilot light is kept burning to make sure that air is not being sucked back.

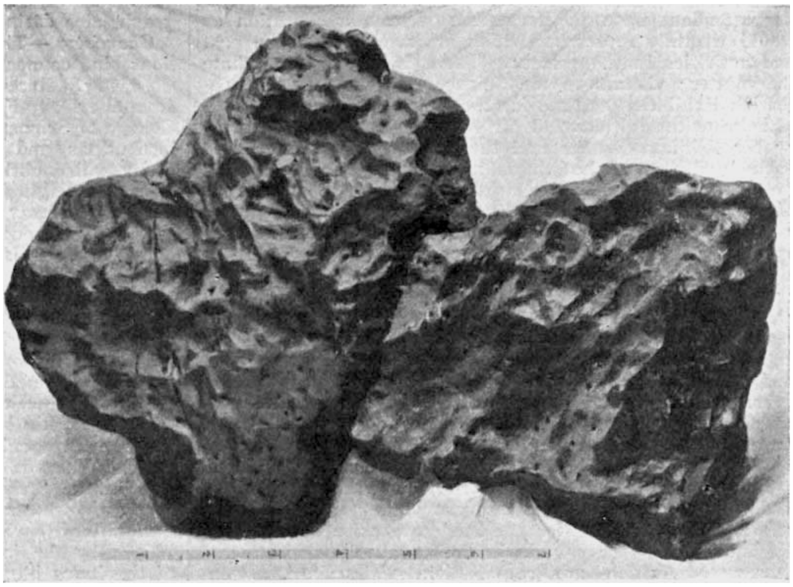
The process has been found successful for decorating porcelain and metallic surfaces with a brilliant coating of zinc. The remarkable part about the action of zinc powder upon metals is the manner and speed with which it, at temperatures much below its melting point, sinks into and alloys with them. In this, Sherardising rather resembles Sir W. Roberts-Austen's experiment in which he placed pieces of gold and lead together, and showed that diffusion took place even at ordinary temperatures; in his case, however, the diffusion was very slow. But with the Sherardising process the zinc sinks in in a few minutes to an appreciable depth. Another peculiarity is that the zinc does not require to be pure, but is the commercial dust which is coated with oxide, and with this zinc dust I have found that it is practically impossible to get an electric current to pass through even a centimetre thickness, although 100 volts pressure was employed. Cadmium and a few other metals can also be employed, but they are not so satisfactory as zinc.

It looks as if the zinc has a very distinct vapour pressure even a very long way below its melting point, not to say its boiling point. The zinc vapour being immediately able to alloy with the iron or other metal in contact with it, equilibrium is destroyed, and a further portion of the zinc becomes vaporised. F. M. P.

STUDIES OF SOME AMERICAN METEORITES.

THE large crater, three-quarters of a mile across and 500 feet in depth, near Canyon Diablo, in Arizona, which it is supposed was produced by the impact of an enormous meteorite, has already been described at some length in Nature (1906, vol. lxxiv., p. 490). Since that date the locality has been visited by Dr. George P. Merrill, of the United States National Museum, and in a paper published in the Smithsonian Miscellaneous Collections (1908, vol. l, pp. 461–90, with fifteen plates) he gives the results of his observations, and reviews the evidence for and against the meteoric hypothesis. In the hope of finding a large mass of metallic nickel-iron, Messrs. D. M. Barringer and B. C. Tilghman have made a detailed examination of the crater, and have put down a number of bore-holes to the depth of 1100 feet in its floor. Beneath the surface débris from the sides of the crater there is a thick bed of lake deposits; this lies on a crushed and pulverised sandstone containing fused and pumiceous fragments and particles of nickel-iron, while at a depth of about 600 feet the undisturbed red sandstone of the district was met with. No large mass of meteoric iron was encountered; and with the exception of four small pieces, the numerous masses of Canyon Diablo meteoric iron have all been found outside the crater. All the evidence undoubtedly points to the crater having been formed by the impact of a meteorite.

Prof. O. C. Farrington, in his "Meteorite Studies, II.," published in the geological series of the Field Museum of Natural History (Chicago, 1907), gives a collection of miscellaneous notes respecting nine different meteoritic falls in the North and South American con-



Mass produced by joining the two individuals of the Chupaderos meteorite. $\times \frac{1}{36}$.